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**MORBIDITY AS A FACTOR IN THE
OPERATIONAL EFFECTIVENESS OF COMBAT SHIPS**

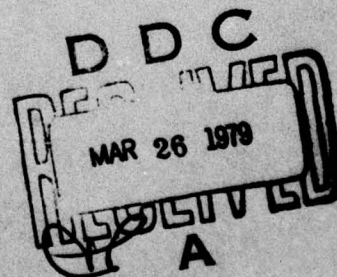
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REPORT NO. 76-8

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NAVAL HEALTH RESEARCH CENTER

SAN DIEGO, CALIFORNIA 92152

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND

BETHESDA, MARYLAND

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Morbidity as a Factor in the Operational Effectiveness of Combat Ships

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THE Navy, unlike other industrial organizations, does not manufacture a product. The Navy's only "product" is readiness to defend the country from attack. This product is difficult to measure, especially in peace-time. Any attempt to measure the degree of readiness of naval units must focus on the concept of operational effectiveness—the capacity to perform a designated mission or function with speed and precision. Operational effectiveness is dependent upon two highly interdependent components, machines and men.

Aboard Navy ships, numerous procedures are employed to monitor the functioning of machines and electronic equipment, so that major breakdowns and resulting losses in operational effectiveness can be avoided. Efficiency in machine maintenance and proficiency in machine operation are essential to sustain the effectiveness of operational units; adequate maintenance and proficient operation are contingent upon trained, motivated, and healthy crew members.

During the past decade, the Navy has demonstrated increasing concern for the men behind the machines, making changes with respect to rules of conduct, personal appearance, uniforms, and, perhaps more importantly, living and working conditions aboard ship. It is generally recognized that poor habitability conditions can affect motivation and performance and, therefore, impair operational effectiveness. However, little can be done to improve habitability conditions aboard older ships, and the problem is one of anticipating the effects of adverse environments upon crew health and behavior, and assisting crew members to adapt to these conditions with minimal loss of effectiveness. A high standard of medical care, including active prevention, is an essential element in sustaining crew effectiveness. Days lost from duty because of illness or accident result in impaired operational effectiveness, just as in industrial settings sick days result in production losses.

If operational effectiveness is contingent upon the physical and mental well-being of the crew, it is just as important to determine situational factors that lead to increased morbidity as to identify mechanical deficiencies that lead to equipment breakdowns. Reliable measurement of illness incidence and environmental conditions is essential if factors that result in reduced operational effectiveness are to be identified, understood, and better controlled. To this end, numerous studies at the Naval Health Research Center, San Diego, have sought to identify causal factors in morbidity

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Report Number 76-8, supported by the Naval Medical Research and Development Command, Department of the Navy, under Research Work Unit MPN03. 08-3014.

NAVY MEDICAL RESEARCH UNIT
SAN DIEGO, CALIF. 92152

NAME _____ DOB _____ DATE _____

AGE _____ PAY GRADE _____ STATUS _____

FOR CORPSMAN USE ONLY

SELECT ONE ☐ 1 NEW VISIT ☐ 2 FOLLOW UP (14)

DISPOSITION ☐ 1 DUTY ☐ 3 SICK LIST (A) ON BOARD

SELECT ONE ☐ 2 BIRNACLE LIST/ ADMITTED TO QUARTERS ☐ 4 SICK LIST (B) NAVYOSP/OTHER

NO. DAYS _____

NOTE: Corpsman please check appropriate box on back of this form.

1 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37

SICK CALL CHECKLIST
1100-CBM-418/1 (REV. 5/78)

NO 184015

RESPIRATORY		VENEREAL		DRUG AND ALCOHOL USE	
INFLUENZA	01	GONORRHEA	20	ALCOHOL	37
PHARYNGITIS-TONSILLITIS	02	SYPHILIS	21	BARBITURATES	38
U. I.	03	CHANCROID	22	NARCOTIC DRUGS	39
OTHER RESPIRATORY DISEASES	04	LYMPHOGRANULOMA VENEREUM	23	NON-NARCOTIC DRUGS	40
MAY FEEL VER. ASTHMA	05	GRANULOMA INGUINALE	24	COMBINATION	41
SKIN		GENITOURINARY		GASTROINTESTINAL	
DERMATITIS	06	NON-GONOCOCCAL URETHRITIS	25	FOOD POISONING	42
CELLULITIS	07	HEMATIA	26	DIARRHEA	43
DERMATOPHYTOSIS	08	PIYERIA	27	OTHER G. I. CONDITIONS	44
ALLERGIC DERMATITIS	09	OTHER G. U. CONDITIONS	28		
OTHER SKIN DISEASES	10				
OTHER		ACCIDENTS AND TRAUMA		PARASITIC INFESTATION	
ADVERSE EFFECTS OF IMMUNIZATION	11	BATTLE CASUALTY	29	INTESTINAL PARASITES	45
ADVERSE EFFECTS OF MEDICATION	12	EFFECTS OF HEAT, LOCAL	30	PELVIC/GENITAL	46
BEHAVIORAL CONDITIONS	13	EFFECTS OF HEAT, SYSTEMIC	31	SCABIES	47
FEVER OF UNKNOWN ORIGIN	14	EFFECTS OF COLD	32		
GERMAN MEASLES	15	AUTOMOBILE	33		
MALOCCLUSION COMPLAINTS	16	MOTORCYCLE/SCOOTER/BIKE	34		
ONSET	17	SHIPBOARD	35		
OTITIS EXTERNA	18	OTHER INJURIES OR ACCIDENTS	36		
OTITIS MEDIA	19				

Fig. 1. Sick Call checklist.

aboard naval combat ships. In one series of studies conducted aboard three cruisers, two aircraft carriers, and a battleship during the Vietnam conflict, a number of demographic and military status variables (age, length of service, pay grade, race, education, General Classification Test score, and job specialty) were shown to influence illness rates aboard ship.^{1,3,8,9,11} Illness rates were especially high for inexperienced men who worked in hostile environments or who performed hazardous and physically demanding jobs.

In these earlier studies, difficulties in obtaining complete and accurate reporting of sick call visits were noted. In spite of efforts to improve routine record-keeping by means of special instructions given by research staff, gaps and inconsistencies in illness recording remained. For example, the Medical Department of one cruiser did not consistently record minor respiratory conditions such as "sore throat" or "head cold," so that the incidence of these common complaints could not be estimated on that ship.¹⁰

In the present study, a specially designed individual data card was utilized aboard all ships studied to record sick call visits. The purpose was to attain better standardization and more complete recording of information for each illness episode than was possible with routine sick call records. This objective was generally achieved. The contents of the sick call card will be described in the Methods section.

In the present study, the investigators examined variations in morbidity rates in relation to operational conditions

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and situational factors during overseas deployments of Navy combat ships. Two categories of morbidity, gastrointestinal disorders (G.I.) and trauma, account for a substantial number of days lost aboard ship and may constitute a significant drain on shipboard manpower during deployment. By comparing G.I. and trauma rates for various phases of the operational schedule, patterns may become apparent in relation to time, location, or type of ship activity which suggest relationships between environmental or situational variables and specific illness rates.

Methods

Enlisted crew members of five destroyer escorts ($N = 864$) were subjects for the study. The ships were all of the same age, size, and class, were deployed to the Western Pacific on about the same dates, and had similar operational schedules. Research staff members boarded each ship early in its deployment to administer questionnaires to crew members and to establish procedures for collecting medical and personnel data. Questionnaire items were concerned with biographical information, military and occupational status, job attitudes, organizational climate, and perceptions of shipboard habitability. The background, goals, and data collection procedures of the complete study have been described elsewhere.^{4,6}

Sick call data were recorded by the ships' Medical Departments, using the special form card designed for this research project (Fig. 1). The front of the card provides identifying information filled out by the patient (name, social security number, date, rate, pay grade, and division). The corpsman on duty fills out three items of information on the front of the card (new visit versus follow-up, disposition, and number of days on the binnacle list or sick list), and indicates the diagnosis or specific condition in the appropriate box on the back of the card. The format for recording specific conditions or illnesses on the back of the card is identical to that for the Monthly Outpatient Report submitted to the Bureau of Medicine and Surgery by all

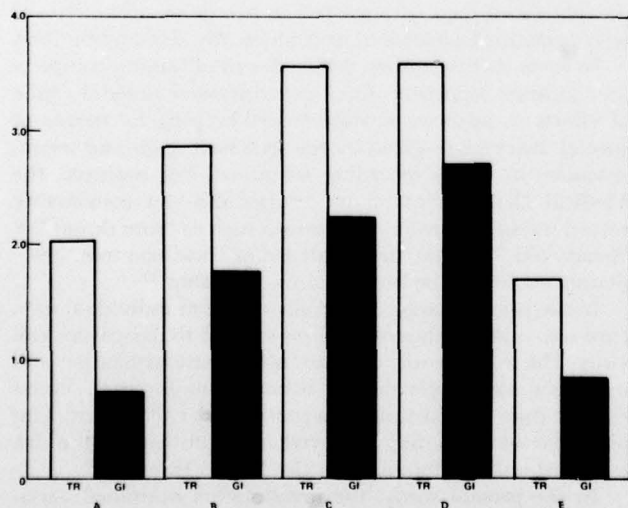


Fig. 2. Illness rates for trauma and gastrointestinal disorders by ship.

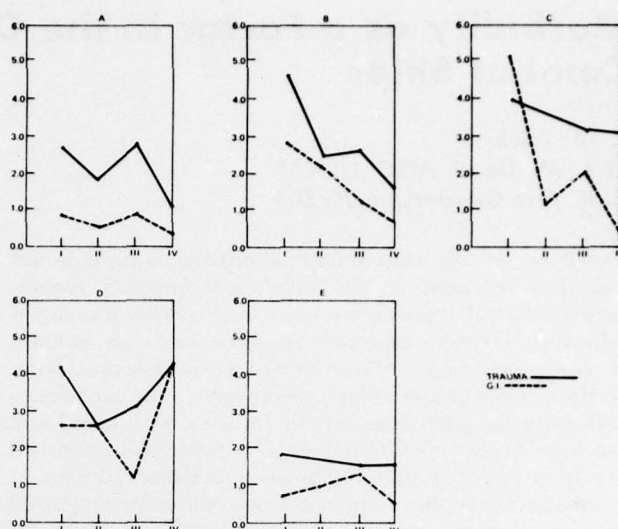


Fig. 3. Illness rates for individual ships by quarter of deployment.

ships and stations. This format was chosen because corpsmen are familiar with these illness categories, and because use of the cards could facilitate preparation of the Monthly Outpatient Report and thus serve as an incentive for accurate recording. Individual and group illness rates were compiled from the sick call cards and information pertaining to days lost from duty was obtained from the same source. Because of the varying lengths of time involved in the operational activities to be compared, illness rates were expressed as the number of new cases per 1,000 men per day.

Operations Departments aboard the five ships provided deployment logs which gave accounts of daily operational activities. Information from the deployment log made it possible to calculate rates of occurrence for gastrointestinal disorders and trauma within specific time frames and under designated situational or operational conditions. For each ship, G.I. and trauma illness rates were computed by quarter of deployment, sea periods versus port periods, and pay grade level.

Results

Incidence rates for trauma and gastrointestinal disorders over the entire deployment are shown for the five ships in Fig. 2. The incidence for trauma was higher than that for G.I. on all ships. Ships varied considerably in incidence rates for both trauma and gastrointestinal disorders. Ships high on trauma were high on G.I. disorders and ships low on trauma also were low on G.I. illnesses.

Incidence rates for each ship by quarters of the deployment are shown in Fig. 3. Although there is variability among ships, incidence rates tended to be high early in the deployment, lower in the second quarter, slightly elevated in the third quarter, and low in the final quarter. Ship D was atypical with its lowest rate of G.I. in the third quarter and a relatively high rate of trauma in the last quarter, and Ship E showed little variability over the four quarters of the deployment.

Incidence rates for each ship by quarter of deployment and pay grade level are shown in Table 1. For trauma there tended to be large differences in incidence rates between rated (petty officer) and non-rated groups; lower rated men, inexperienced in their jobs and unfamiliar with the ship-board environment, had many more injuries than petty officers, particularly in the first quarter of the deployment. Only in one quarter for one ship did the rated group have more trauma than the non-rated group.

For gastrointestinal disorders, the incidence rate for non-rated men was only slightly higher overall than that for rated men, and there were no consistent differences across ships or quarters of deployment. Thus, pay grade level was an important factor in rates of trauma but a negligible factor in rates of G.I. disorders.

Gastrointestinal infections are likely to occur only when ships are in port. Accidents and traumatic injuries, on the other hand, may occur at any time at sea or in port. It was of interest to determine the relative risk of injury at sea or in port. Differences in the trauma rates at sea and in port for each ship over its entire deployment are shown in Fig. 4. For three of the ships, the differences between trauma rates for port and sea periods were minimal; for the other two ships differences were substantial and in opposite directions. Ship B incurred a higher incidence of trauma during operational activities at sea, while Ship D reported more injuries in port. More detailed information concerning ships' and crews' activities are needed to account for such differences from ship to ship. For example, the elevated trauma rate for Ship B at sea was largely attributable to several cases of sunburn early in the deployment; also, it was noted that many of the injuries reported for crew members of Ship D were incurred on repeated visits to a single port, although the types of activities precipitating the trauma were unknown.

The incidence of gastrointestinal disorders was hypothesized to be primarily a function of specific ports visited. Preliminary examination of the G.I. illness rates during and immediately following all port visits in the Western Pacific indicated that two ports, which were visited by all five ships,

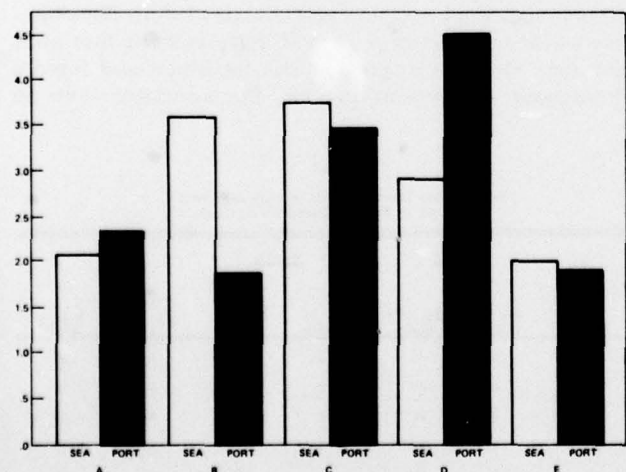


Fig. 4. Rates of trauma by ship and by At Sea versus In Port.

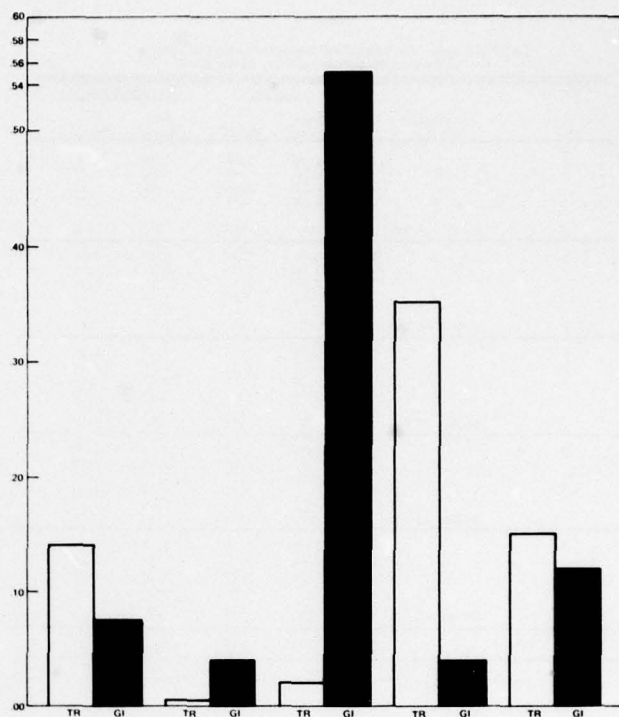


Fig. 5. Rates of days lost for trauma and gastrointestinal disorders by ship.

presented relatively high risks for G.I. disorders. The hypothesis that visits to these two ports largely accounted for differences in G.I. rates was tested by comparing ships with respect to numbers of visits and total numbers of days in these ports as shown in Table 2. It can be seen that, except for Ship E, there is a linear relationship between visits and days spent in the high risk ports and rates of gastrointestinal disorders. Ship A visited the two ports for only 10 days and had a very low rate of gastrointestinal illness, while Ship D visited these ports for a total of 54 days and had a high rate of G.I. disorders. Ship E, however, spent the most days in these two ports but had a relatively low G.I. rate. At the same time, G.I. incidence rates were consistently elevated for Ship E during and after most of its visits to these ports; nevertheless, the overall G.I. rate for the entire deployment remained low for this ship. The specific factors that could account for this apparent anomaly are not known at this time, and further study of these relationships obviously is needed.

Rates of days lost as a result of trauma and G.I. disorders for each ship during its entire deployment are shown in Fig. 5. Overall, G.I. disorders were responsible for a greater loss of man-hours than trauma, although one ship (Ship C) contributed disproportionately to this difference. The most striking result was the wide variability in days lost from ship to ship and the extreme variability by specific illness category. There was a general correspondence in total days lost in relation to combined illness rates except for Ship B, which had extremely low rates of days lost for both G.I. and trauma. This low rate for Ship B suggests either a difference

Table 1
Incidence Rates for Trauma and Gastrointestinal Disorders
by Quarters of Deployment and Pay Grade Level^a

Ship	Deployment Quarter	Trauma		Gastrointestinal	
		Non-Rated ^b	Rated ^b	Non-Rated ^b	Rated ^b
A	1	4.63	1.18	1.18	.68
	2	2.56	.83	.41	.57
	3	3.84	1.86	.61	.95
	4	1.13	.93	.62	.34
	Number of Men	95	116	95	116
B	1	5.00	2.68	4.22	1.87
	2	2.94	2.20	3.17	1.38
	3	3.11	2.45	1.47	1.41
	4	2.94	.87	1.42	.11
	Number of Men	61	74	61	74
C	1	4.71	3.26	5.62	4.16
	2	3.84	2.91	1.21	1.30
	3	6.14	1.57	2.09	2.96
	4	3.18	3.33	.23	.59
	Number of Men	88	102	88	102
D	1	4.75	2.92	3.36	6.83
	2	3.96	1.85	2.74	2.49
	3	4.46	2.37	1.59	1.05
	4	5.13	3.67	4.49	4.10
	Number of Men	60	89	60	89
E	1	2.89	1.29	1.16	.38
	2	2.41	1.30	.80	1.14
	3	1.67	1.57	2.28	.55
	4	2.07	1.39	.85	.35
	Number of Men	68	111	68	111
Totals		3.59	1.97	1.87	1.54

^aThe incidence rate is the number of new cases per 1,000 men per day.

^bNon-Rated - pay grades E-1 through E-3; Rated - pay grades E-4 through E-9.

in Medical Department or command policy with respect to time off for illness on Ship B, or systematic underreporting of days lost by the Medical Department of this ship.

The possible impact of morbidity on a ship's effectiveness can be illustrated in the case of the epidemic of gastroenteritis that hit Ship C during a visit to one of the high risk ports (Port Y). The extent and severity of this epidemic are reflected in the high G.I. incidence rate and extremely high days lost rate for this ship shown in Figs. 2 and 5. During a period of approximately two weeks early in its deployment (six days in port, one day at sea, three days in port, and four days at sea), Ship C had a total of 58 dispensary visits for G.I. disorders; 52 of these were initial visits, and six were follow-up visits. Of the 52 individual cases, three were officers and two of these were placed on the binnacle (disabled) list. Of the 49 ill enlisted men, almost half were placed on the binnacle list; 26 were petty officers, of whom 10 were placed on the binnacle list. The Supply, Engineering and Hull, and Operations Departments each had 12 men ill; the larger Supply and Engineering and Hull Departments presumably were less affected than the Operations Department, where a loss of 12 men would be critical for operational effectiveness. It is clear that this ship was forced to operate at a decreased level of effectiveness for a short period because of the G.I. epidemic experienced in one high risk port.

Discussion

Fleet readiness, or the operational effectiveness of combat ships, depends upon optimal physical and mental fitness of ships' crews throughout periods of deployment. Illnesses, injuries, or other incapacitating states can reduce operational readiness, especially as manning levels are reduced by man-

power constraints. In addition, shortages of professional medical personnel make mandatory the most efficient systems for distribution and utilization of such personnel in support of fleet units.

In order to plan adequate medical support for fleet operations, a forecast model for casualties during operational deployments appears essential. Such a model does not exist at the present time. The Naval Health Research Center has conducted a series of studies of personnel characteristics and shipboard stresses in relation to illness rates and adjustment problems aboard a variety of combat ships.² The results have consistently shown differential rates of health problems among crew members in relation to age, experience, type of job, ships' physical characteristics, and type of operational activity. The present study extended these investigations to consider additional aspects of the deployment cycle, such as particular ports visited, and to examine the impact of these operational activities upon specific categories of illness rather than general illness rates.

In order to accurately measure illness incidence rates and to evaluate the effects of various environmental and operational factors upon health, reliable methods of recording shipboard morbidity are required. Because of variability in reporting methods from ship to ship, imprecise diagnostic classification, and the absence of any individual identifying information, the present monthly outpatient reporting system provides an inadequate data base for studies of differential incidence rates. The individual sick call card used in the current study represents an important advance in methods of recording medical data aboard ship, but further modifications are needed, primarily to provide greater reliability and specificity of diagnostic classification, to make this a more sensitive and useful instrument.

From the findings of this and previous studies, it appears feasible to develop a forecast model for predicting casualties during operational deployments which would include the following parameters: (1) age, physical characteristics, and class of ship; (2) mission and technology (weapons system) of ship; (3) crew composition (types of jobs, experience levels, attitudes); (4) operational schedule of ship (geographical and seasonal aspects, deployment phases by type of activity, deployment duration, specific ports visited); and (5) organizational structure and climate of ship. The objective would be to develop methods for predicting fleet units and crew elements at greatest risk for illness and injuries throughout deployment periods, the associated costs in

Table 2
Relationship between Visits to High Risk Ports
and Rate of Gastrointestinal Disorders

Ship	Port X		Port Y		Total No. of Days	G.I. Rate ^a
	No. of Visits	No. of Days	No. of Visits	No. of Days		
A	3	9	1	2	11	.67
B	4	33	1	6	39	1.81
C	5	26	3	18	44	2.38
D	8	47	1	7	54	2.68
E	9	46	1	9	55	.86

^aThe incidence rate is the number of new cases per 1,000 men per day.

man-days lost and personnel turnover, and the adequacy of preventative measures and health care aboard ship. Item 5 of the parameters pertaining to organizational climate implies the recognition of crew members' *perceptions* of their physical and social environment as important in the prediction of behavior.^{5,7}

The overall incidence of medical problems aboard the five ships affected approximately two per cent of the total crew per day; rates varied widely, however, and were not evenly distributed with respect to time, place, work group, or type of casualty. The consequences of various patterns of illness-accident occurrence aboard ship have not been well-defined in terms of crew readiness and operational effectiveness. The development of the proposed casualty forecast model would aid commanding officers and medical personnel to be alert to environmental and operational conditions that may adversely affect the health or readiness of crew members and thus impair ship effectiveness.

Acknowledgments

The authors wish to express their appreciation to Gloria M. Lynch and Lawrence A. Hermansen for valuable technical assistance. The important contribution of CDR Paul D. Nelson, MSC, USN, also is gratefully acknowledged.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 76-8	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Morbidity as a Factor in the Operational Effectiveness of Combat Ships,		5. TYPE OF REPORT & PERIOD COVERED Interim
7. AUTHOR(s) Jeanne M./Erickson, Larry M./Dean E. K. Eric/Gunderson		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Health Research Center San Diego, California 92152		8. CONTRACT OR GRANT NUMBER(s) MPN03
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Medical Research and Development Command Bethesda, Maryland 20014		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS MPN03-08-3014
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Bureau of Medicine and Surgery Department of the Navy Washington, D.C. 20372		12. REPORT DATE January 1976
		13. NUMBER OF PAGES
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited. NAVHRLTHRSCHC-76-8		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Naval environments Environmental effects Morbidity Accidents Gastrointestinal disorders		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Variations in morbidity rates were examined in relation to operational conditions and situational factors during overseas deployments of five Navy combat ships. Comparisons of gastrointestinal disorder and trauma rates for various phases of the operational schedules indicated that G.I. incidence is primarily related to specific ports visited while trauma incidence is more a function of time of deployment, operational activity, pay grade, and job assignment. The findings of this study imply that in order to evaluate the		

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effects of environmental and operational factors upon health, more reliable methods of reporting shipboard morbidity are required. Parameters for a forecast model to predict deployment casualties are suggested.

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